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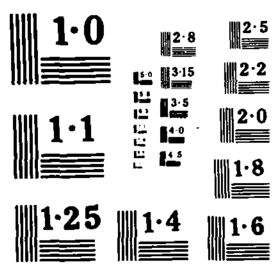
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P.J. Mulhearn

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ABSTRACT

Results from a 99 day deployment of a recording current-meter 100 m above the bottom on the Tasman Abyssal Plain are presented. Strong southwards currents, up to 37.1 cm/s, were encountered. Kinetic energies are comparable with those found at abyssal depths under the Gulf Stream and the Kuroshio. Tidal currents are weak, of order 1 cm s^{-1}.

Technical memoranda are of a tentative nature, represent the views of the author(s), and do not necessarily carry the authority of the Laboratory.

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Introduction

To the author's knowledge no long-term current-meter measurements, obtained prior to those discussed here, have been reported from abyssal depths in the Tasman Basin. A times series, obtained concurrently with this one, of zonal bottom currents derived from measurements of ambient vertical electric field fluctuations is reported in Bindoff et al (1985). Laird and Ryan (1969) report current-meter measurements over only 70 minutes for a site at 30°57.9'S, 155°00.8'E at 4572 m depth. Long term velocity measurements down the New south Wales continental slope to 2000 m depth were obtained during the Australian Coastal Experiment (Clarke and Thompson, 1984).

From 13 December 1983 to 21 March 1984 (99 days) an RCM-5 Aanderaa recording current-meter was deployed at 35°54'S, 151°23'E, 100 m above the bottom in 4850 m of water (see Fig.1). This meter was deployed as part of the Tasman Project of Sea Floor Magnetotelluric Exploration (Ferguson et al, 1985). The low frequency (sub-tidal) velocity fluctuations from the current-meter have been compared with other abyssal observations, and with the motion of the East Australian Current and an associated warm-core eddy in Mulhearn et al (1986). Figure 2 shows the time series of the zonal and meridional velocities, to which a Munk "tide-killer" filter have been applied. The present paper mainly considers fluctuations at tidal and higher frequencies. Bindoff et al (1985) concentrate on this frequency range in their discussion of results from vertical electric field measurements obtained farther east as another part of the Tasman Project of Sea Floor Magnetotelluric Exploration.

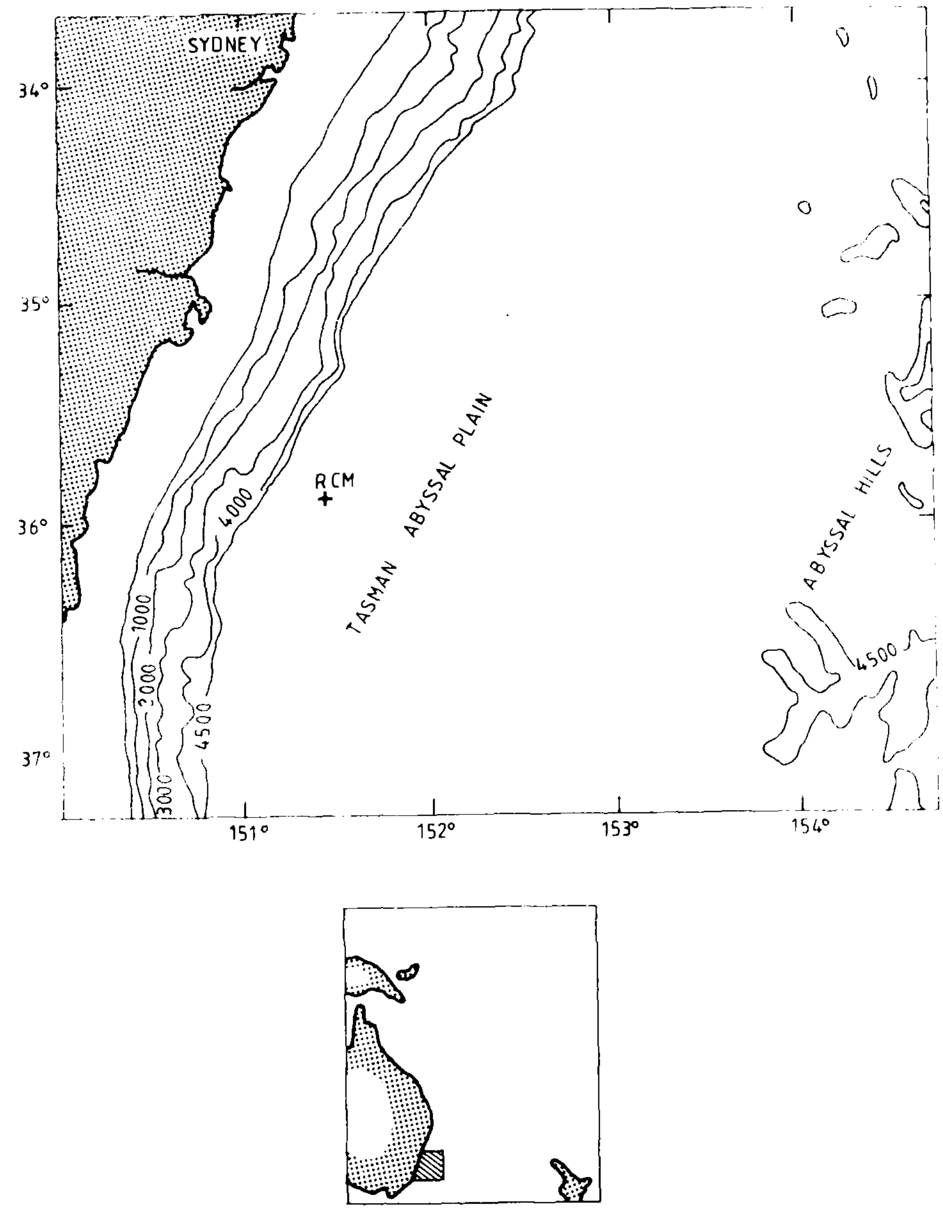


FIGURE 1. MAP SHOWING POSITION OF RECORDING CURRENT-METER (RCM)

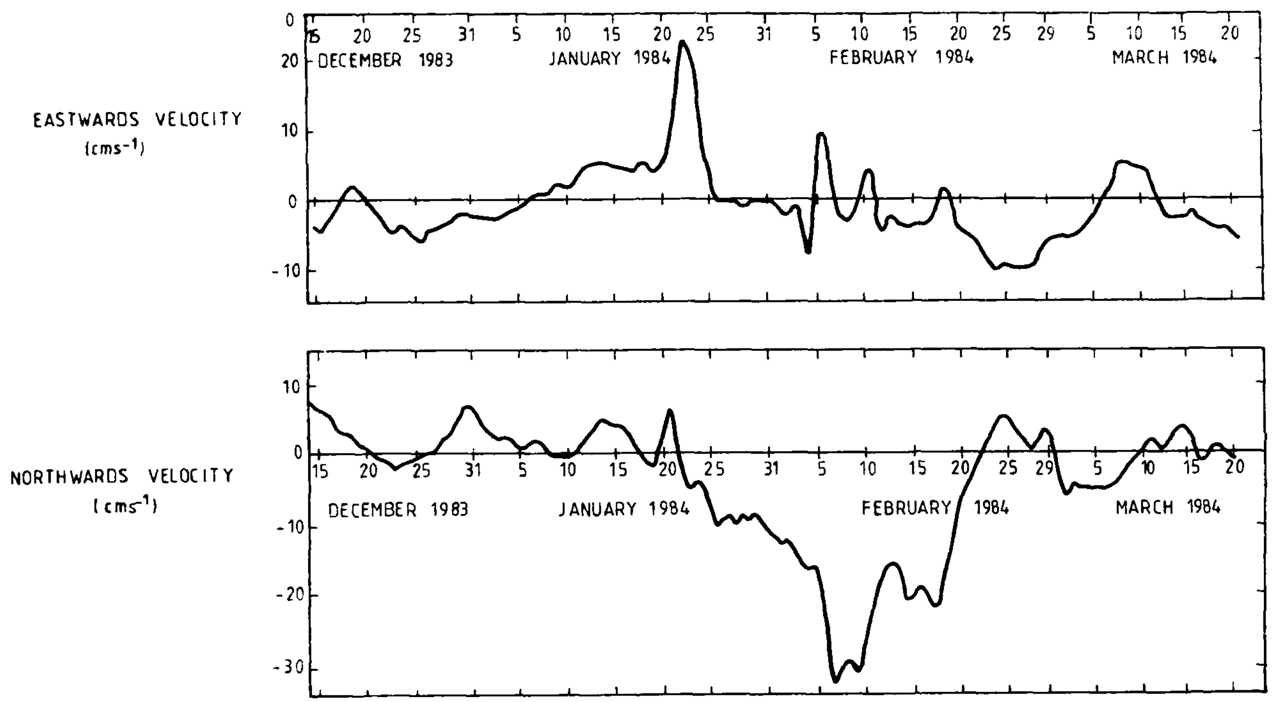


FIGURE 2. VELOCITY TIME SERIES FROM RECORDING CURRENT-METER (TIDE-KILLER FILTER APPLIED).

Equipment and Analysis

The current meter was a standard RCM-5 Aanderaa. Every 15 minutes it recorded instantaneous direction and the average speed over that sampling period. The starting speed was 2 cm s^{-1} and for zero turns of the meter's rotor a speed of 1.5 cm s^{-1} was recorded. There were periods with flow less than 2 cm s^{-1} but such sections of the time series should not have a great effect on the overall statistics as they only represent 7% of records. Spectral and tidal analyses were restricted to the longest period (59 days) with currents above 2 cm s^{-1}. The meter was moored via an AMF Sea-Link Model 322 recoverable acoustic transponder to a number of cast iron weights, and had glass floats attached for buoyancy.

The record was analysed to produce standard statistics and histograms, power spectra and tidal components.

Results

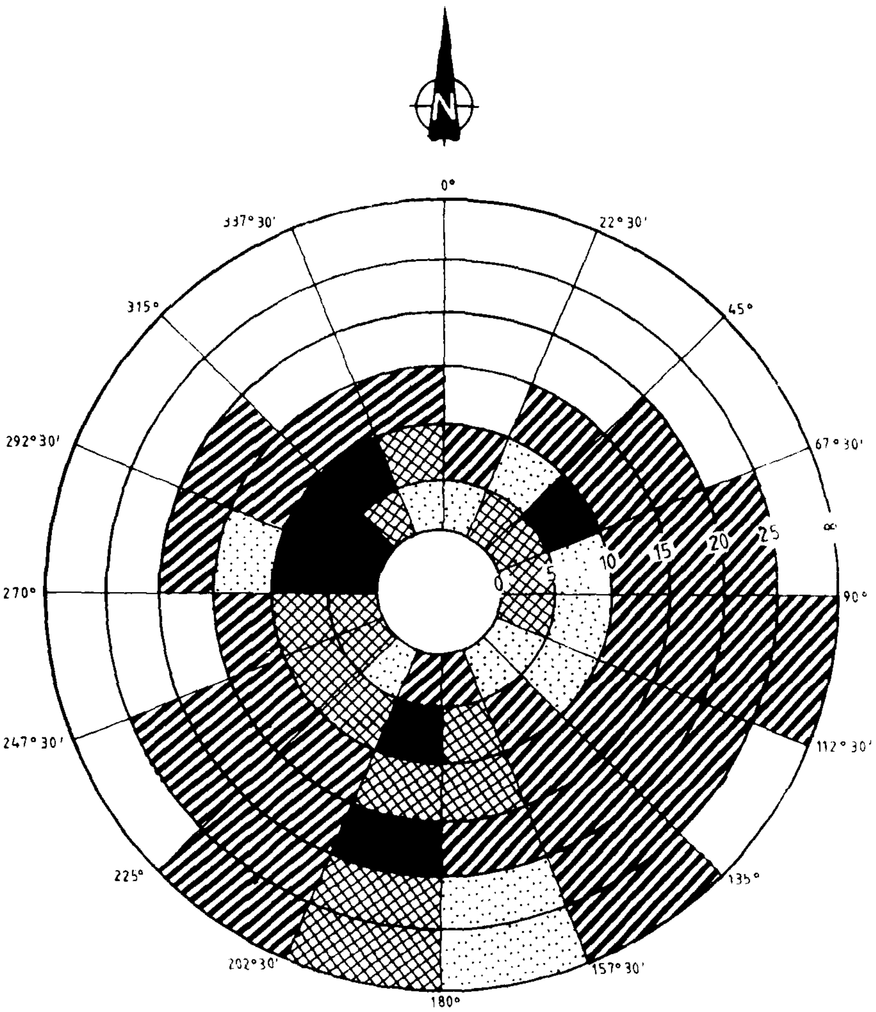
Statistics from the whole record length are presented in Table I. The average current direction of 198° is within 9° of being parallel to the isobaths of the nearest part of the continental slope. The approximately southward mean direction is an indication of the influence of the East Australian Current system. The mean kinetic energy per unit mass is 8 cm^2/sec^2, the fluctuation kinetic energy per unit mass is 60 cm^2/sec^2 and their ratio is 7.5. These values are comparable with those under the Gulf Stream (Dickson, 1983) and the Kuroshio Extension (Schmitz 1984 a and b).

The current rose (Fig.3) shows that the strongest currents are predominatly southwards and in this direction are usually over 5 cm s^{-1}. Away from the southwards direction speeds are most often less than 10 cm/sec. Detailed histograms show the median speed is 5 cm/sec, and the median direction is 183.6°. The speed histogram is bimodal with a second peak at 19 cm/sec.

Power spectra for the velocity components are shown in Fig. 4. Spectra were obtained in two separate runs. For the low frequency part they were obtained via 1024 point Fast Fourier Transforms on each component using hourly data. For the high frequency section ten spectra obtained via 512 point FFT's on 15 minute samples were averaged for each component. These spectra were obtained in the period after 11 January 1984 when currents were strong enough to keep the rotor turning.

Peaks at diurnal and semi-diurnal frequencies are prominent in the meridional component but are barely visible in the zonal component. There is some evidence of the presence of inertial oscillations ($f = .0489$ cycles/hour) in the "shoulders" on the high frequency side of the diurnal peak. From approximately 0.1 to 0.7 cycles/hour the spectra fall off as $(\text{frequency})^{-2}$ and are approximately equal. These properties are as expected from the Garrett and Munk (1975, 1979) spectrum for internal waves.

The spectral levels in the internal wave frequency-band are typical of those found in deep moorings (e.g. Wunsch 1976). A direct comparison with the Garrett and Munk spectrum cannot be obtained with any accuracy because the buoyancy frequency, N, is not adequately known. From Nansen cast data, obtained when the current meter was deployed, a value for



OVER 300 VALUES IN SPEED - DIRECTION 'BOX'

200 - 300 VALUES

100 - 200 VALUES

1 - 100 VALUES

FIGURE 3. CURRENT ROSE (NUMBERS ON AZIMUTHAL LINES ARE SPEED IN CM S^{-1}) (DATA IS FROM 9507 FIFTEEN MINUTE AVERAGES).

between 0 and 0.9 cycles/hour was inferred. Taking the best line of fit through the in-situ density points gives N = 0.6 cycles/hour. It can be seen that this gives a curve within a factor of three of the data. Taking $N = N_0 e^{-z/b}$, as in Garrett and Munk (1979), with No = 3 cycles/hour, b = 1.3 km and z = depth (km) one obtains a curve approximately a factor of two below the data. However, this gives N = .078 cycles/hour, a 12.8 hour period! Considering the uncertainty in N and the possible errors from Doppler shifting in strong currents and from mooring motion, there is reasonable agreement between the data and the Garrett - Munk spectrum. Beyond 1 cycle/hour the data lie above the $(\text{frequency})^{-2}$ line and appear rather noisy.

Results of tidal analysis are shown in Table II. Where certain components, such as P_1 and K_1, S_2 and K_2, are too close together for them to be distinguished in this limited length of record only that associated with the larger tide generating force is presented. It can be seen that the M_2 component is the largest, followed in order of decreasing magnitude by K_1, S_2, O_1, N_2 and Q_1. However they all represent very small currents.

Acknowledgements

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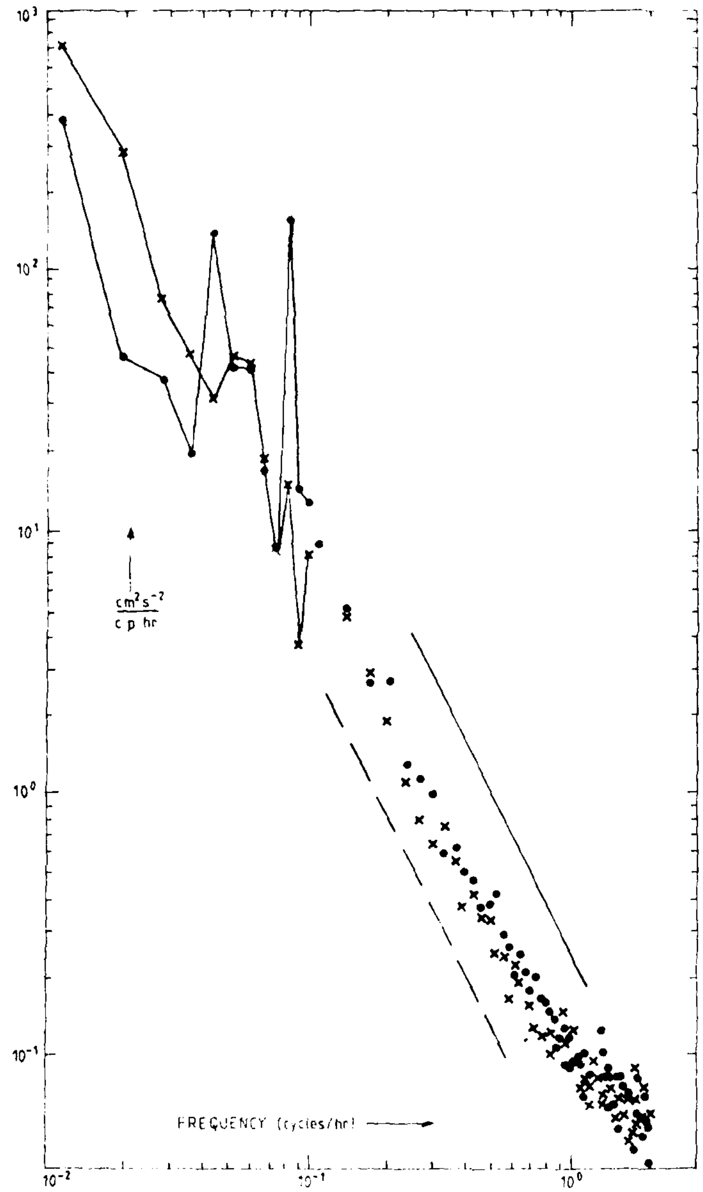

FIGURE 4. POWER SPECTRA OF VELOCITY COMPONENTS: X, ZONAL COMPONENT; ●, MERIDIONAL COMPONENT. FULL LINE IS GARRETT - MUNK SPECTRUM WITH N = 0.6 CYCLES/HOUR. DASHED LINE IS GARRETT - MUNK SPECTRUM USING $N = N_o e^{-z/b}$ WITH N_o = 3 CYCLES/HOUR, B = 1.3 KM, AND Z IS DEPTH (KM).

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Table I

	u	v	Direction	Speed
Minimum	-16.9	-36.3	-	1.5
Maximum	25.6	11.6	-	37.1
Mean	- 0.7	- 3.9	197.6	9.5
Std. deviation	5.6	9.4	92.1	7.3
Skewness	1.3	- 1.3	- 0.2	1.5
Kurtosis	6.6	4.1	2.1	4.6

u is eastwards, v is northwards velocity componet. u, v and speed are in cm s^{-1}; direction is in degrees with 0°being true north

Table II

Component	Period (Hr)	ε (°)	Major Axis (cm s^{-1})	Minor Axis (cm s^{-1})	Phase (°)
Q_1	26.868	6.88	.33	.09	- 57.15
O_1	25.819	-68.18	.59	.01	107.41
K_1	23.9	-75.53	1.10	-.11	142.17
N_2	12.658	-13.76	.36	-.16	-144.28
M_2	12.421	99.41	1.43	-.40	- 19.63
S_2	12.000	-83.33	.66	-.28	175.46

ε is angle of major axis of tidal ellipse with respect to due east, measured anticlockwise.

Phase is lag of major axis current relative to tide generating force at Greenwich.

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